

The electrons in a synchrotron storage ring emit radiation at every bending magnet. The third bending magnet of ALS Sector 1 provides light to the fourth port of that sector, 1.4. This particular port accepts light from the electron beam where the emittances are too large for high-brightness x-ray experiments, but they are still small compared to IR wavelengths. Therefore the "dot 4" ports are excellent as IR beamline ports and no x-ray capabilities are sacrificed at the ALS. It also means that there are plenty of other IR ports available at the ALS for future IR beamlines, should the demand justify building more.

The broad-spectrum synchrotron light exits the bending magnet with an opening angle of 10 mrad in the vertical, and 80 mrad in the horizontal. A water-cooled GlidcopTM aperture allows only one half of this beam to exit (the left half) due to the interference of a downstream magnet on the sector chamber. The remaining 10 x 40 mrad beam exits the storage ring chamber through the 1.4 port.

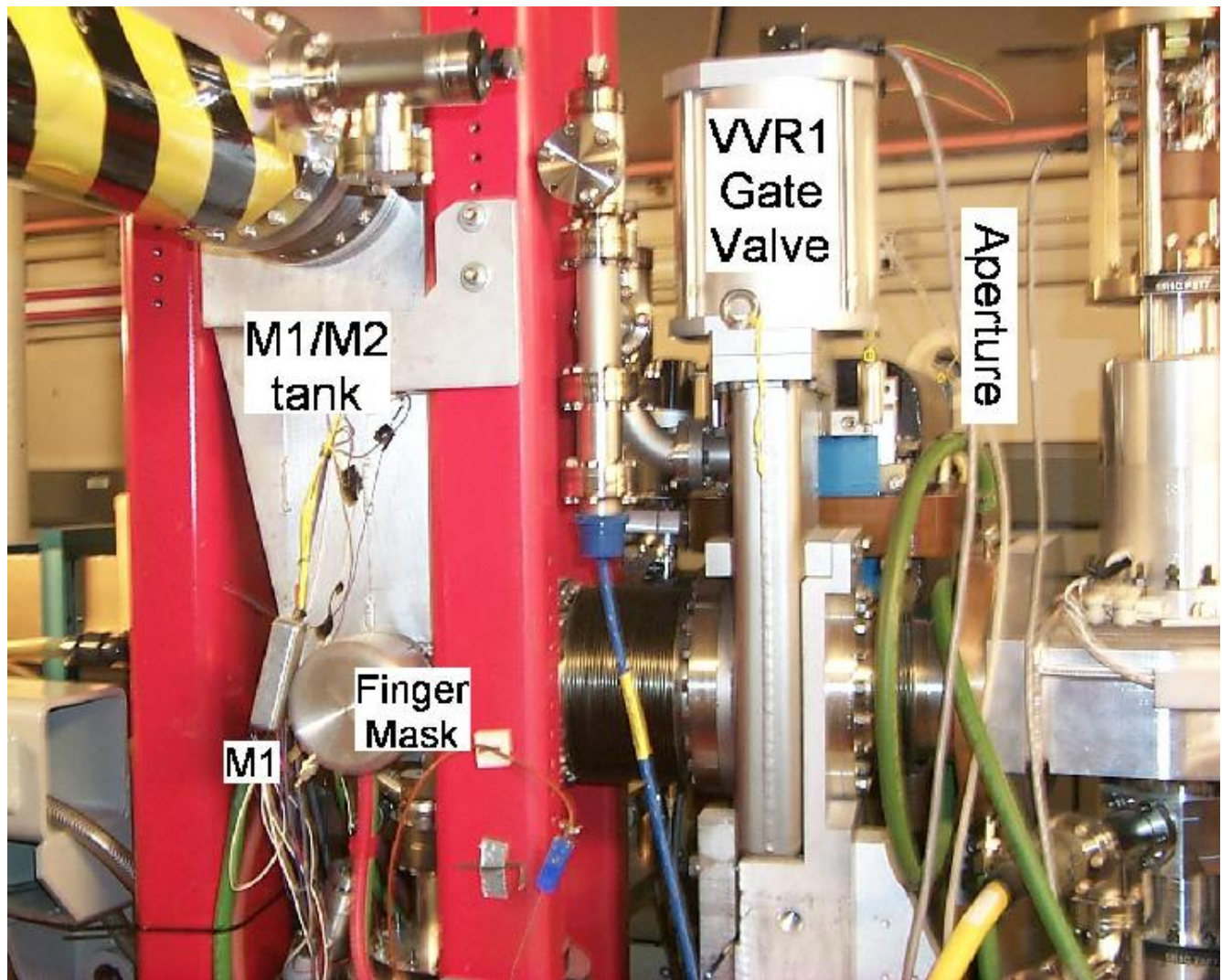


Figure 1: Photograph of the BL1.4 front end.

The first 1.4 front end gate valve, VVR1, is located between the 1.4 port and the first beamline optics (see Figure 1), however it is not capable of withstanding the synchrotron beam. It is therefore only set to close in case of a beamline vacuum leak, and the ring will dump the electrons if this occurs. It may also be closed manually during maintenance periods to protect either the beamline or the sector 1 vacuum chamber when either requires venting.

A finger mask (a small copper pipe with approximately 0.5 gallons of water per minute flowing through it for cooling purposes) is placed directly through the center 1 mrad of the light beam. It therefore removes the central portion of the radiation where all the x-ray and VUV power resides. Roughly 600 of the 620-watt total beam power is dissipated by the finger mask, greatly reducing the heat load on our first mirror, M1. A recirculating chiller behind the 1.4.3 hutch provides cooling water and thermocouples monitor the water temperature before and after the finger mask at all times.

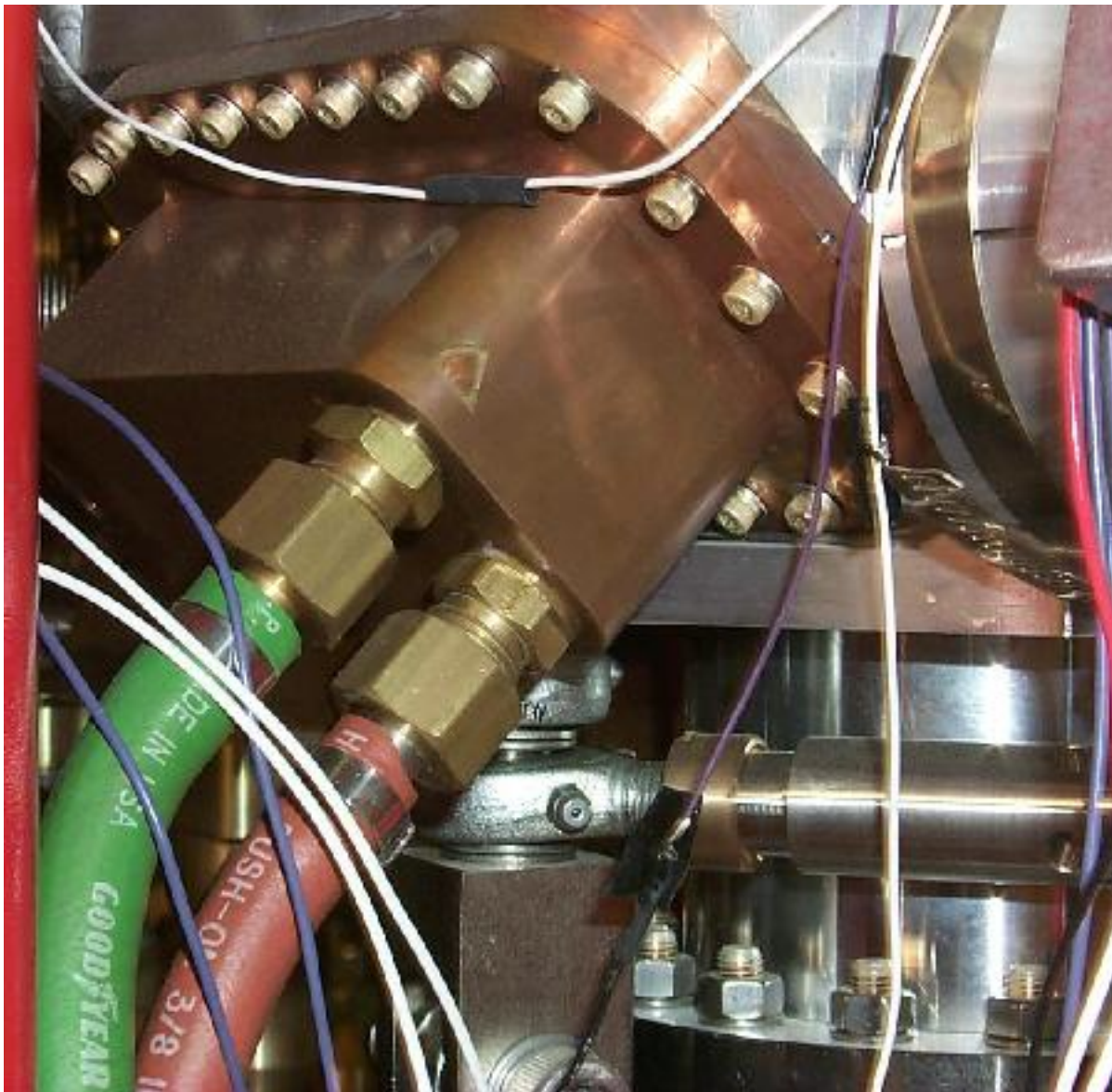


Figure 2. Close-up of mirror M1.

M1 is a water-cooled flat mirror made of brazed Glidcop™ ground, polished and coated with electroless nickel by SESO of France. It is novel in that most of it is located outside the UHV chamber, and the mirror body itself forms the seal with the chamber, with a Helico-flex seal. The mirror is located directly beyond the finger mask and has sufficient water cooling (seen in Figure 2 as the red and green hoses) to handle the direct beam power should the finger mask ever fail, but the mirror would eventually start to warp under these conditions. M1 directs the light beam through a 90-degree bounce up out of the plane of the electrons' orbit. Any hard UV and soft x-rays that get past the finger mask will not reflect at this high an angle and are simply absorbed into the body of M1. The coating on M1 (and nearly all other beamline mirrors) is bare aluminum. The small surface layer of aluminum oxide absorbs any light with wavelengths shorter than about 180nm, and is another safety factor in the design of the beamline.

The light beam from M1 is now incident on M2, which is found at the top of the M1/M2 tank pictured in Figure 1.2. This mirror is made of Zerodur also by SESO, and it directs the light 90 degrees tangentially to the storage ring and outside of the shielding wall. The curvature of the mirror is ellipsoidal having a one-to-one focus at 3.5 meters, the distance from the center of the bending magnet to the mirror, and again from the mirror to the switchyard outside the storage ring-shielding wall. The 0.5-meter rise will allow future x-ray lines from the previous two bending magnets to pass under the IR beamline. A five-inch hole in the shielding wall permits the beam pipe to pass without any lead shielding because of the 0.5-meter vertical difference between the hole and the ring. Measurements show essentially no radiation outside the hole during operation of the ring, and only minimal radiation during injection. The beam passes through a large ion pump just inside the shield wall as shown in Figure 1.4.

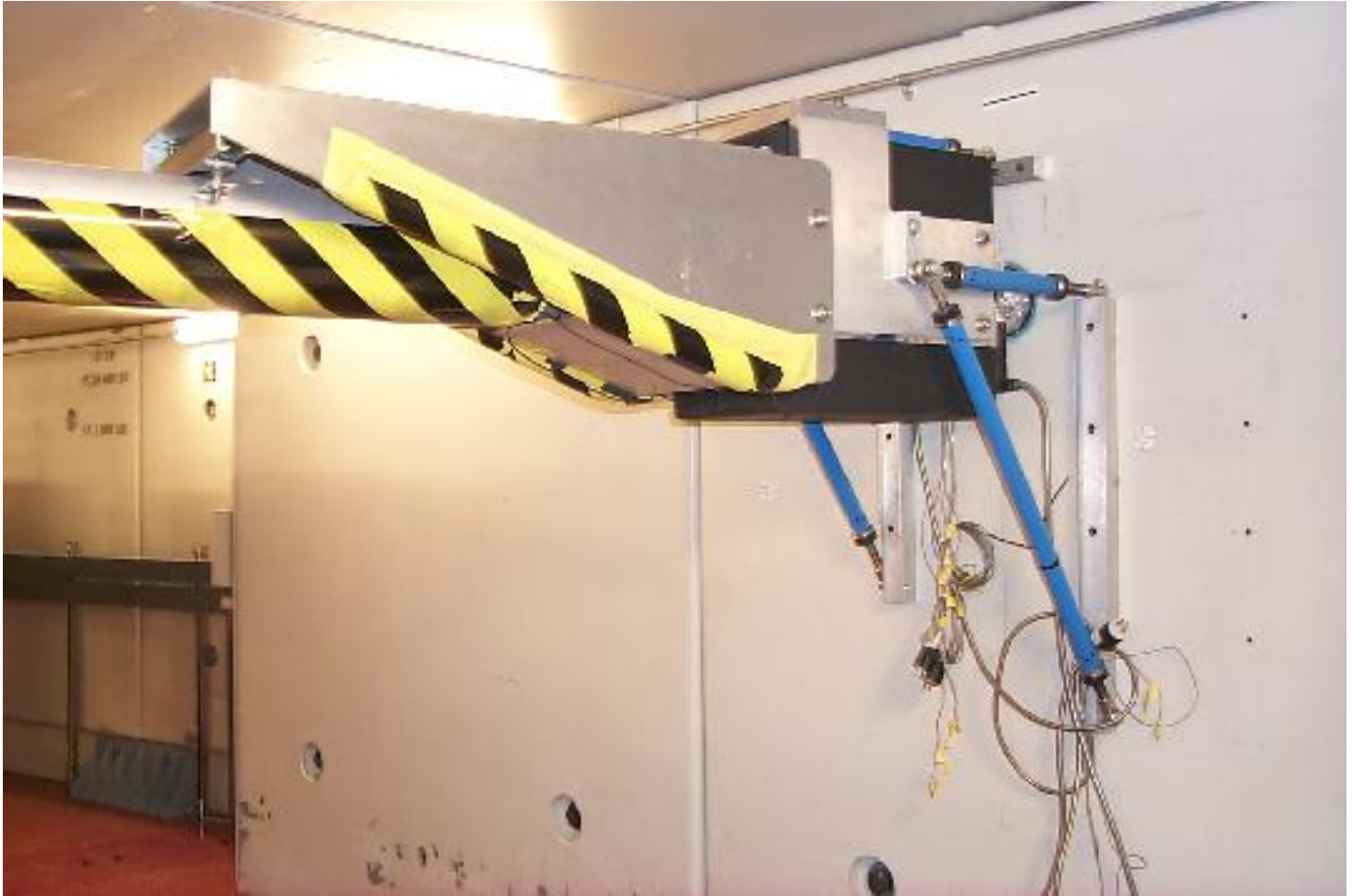


Figure 3. The light beam passes through a large ion pump and then out through a hole in the storage ring shielding wall.

Switchyard

Just outside of the shielding wall, the light beam, which is focusing, passes through a second gate valve, VVR2 (Figure 4). This gate valve has a fused-silica window in the gate allowing a portion of the light to pass even when the valve is closed.



Figure 4. The vacuum connection between the shield wall and the switchyard, as seen from above.

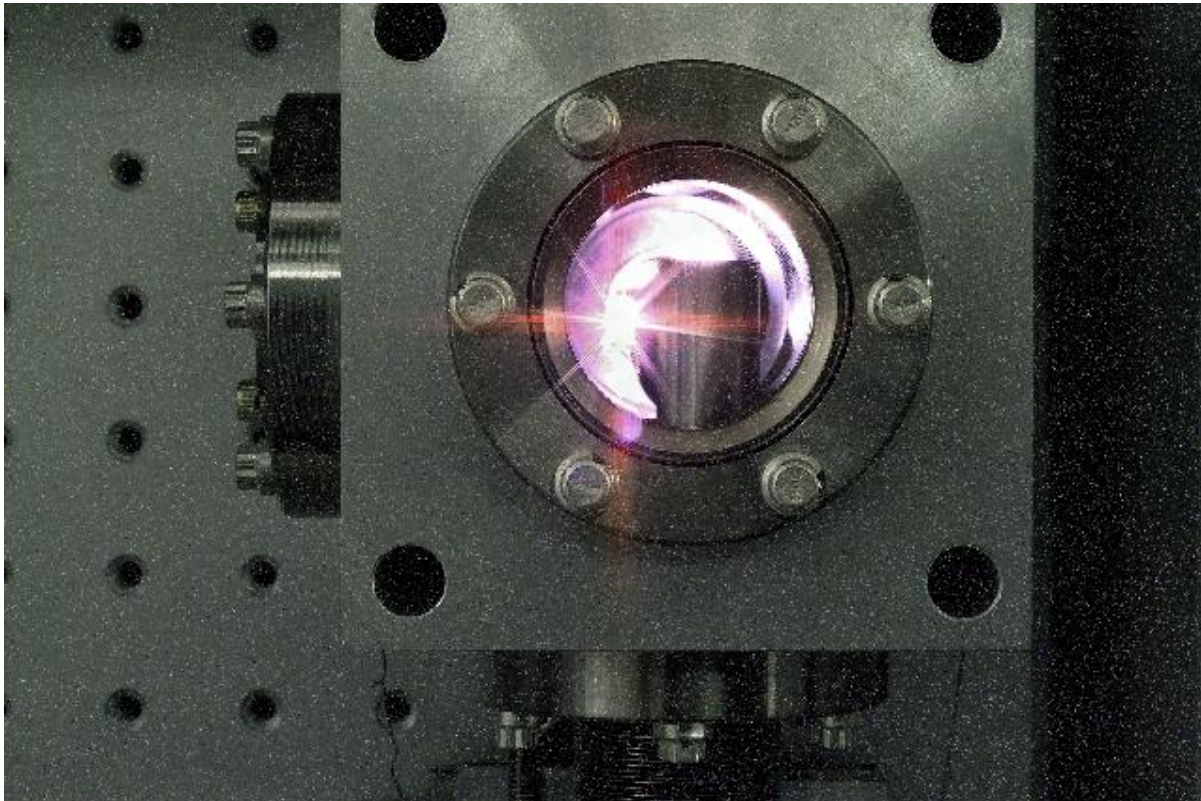


Figure 5. Photo of the UHV cube located just inside the switchyard. The view is looking through the Suprasil™ window back towards the front end. The synchrotron light is visible incident on M3, which is reflecting the light out through the diamond window mounted in the flange to the left. This photo is actually our official "first light" photograph taken on August 26, 1997.

Just beyond VVR2, the light enters into the upper right corner of the switchyard into a small UHV cube pictured in Figure 5. This cube houses mirror M3, a one inch round flat mirror which if in place will send the beam outside of the UHV through a diamond window located in the flange on the far left of the cube in Figure 1.6. The diamond window is 12 mm in diameter and is placed approximately at the focus of the ellipsoidal mirror, M2. It is sealed in indium foil on both sides, and is polished with a one-degree wedge to remove extraneous interference fringes in the FTIR spectra caused by multiple reflections. If mirror M3 is retracted, the light passes through a Suprasil™ window (an ultraviolet grade

fused silica material) and then on to BL1.4.1. The purpose of valve VVR2 is to act as an added measure of safety should the diamond window ever fail, even though this window is rated to withstand three atmospheres of pressure. When-ever the pressure inside the switchyard rises above rough vacuum levels (for example when venting the switchyard), VVR2 is interlocked to automatically close, thus isolating the last small portion of the beamline behind the diamond window from the storage ring vacuum. This means that after the switchyard is closed and pumped out again, VVR2 must be re-opened to allow all the IR light to pass. Call Mike or Hans or the ALS control room in this case as we have keys to open VVR2.

The switchyard itself is seen in Figure 6. It is essentially a vertically mounted optical table inside an aluminum vacuum box. The entire box is mounted via a 6-strut system to a vertical pole (painted black and seen to the right of the switchyard in Figure 6). This pole is water filled to help isolate the switchyard from any vibrations coming through the floor. The switchyard and the vacuum pipes distributing the light beam to the individual spectrometers are pumped via a Varian Scroll pump. The blue object at the bottom of the photo is a weight in the vacuum line that helps dampen out any vibrations coming from the pump. A convectron vacuum gauge on top of the switchyard measures the pressure inside and this pressure is interlocked to valve VVR2 as described above.



Figure 6. Photograph of the BL1.4 switchyard.

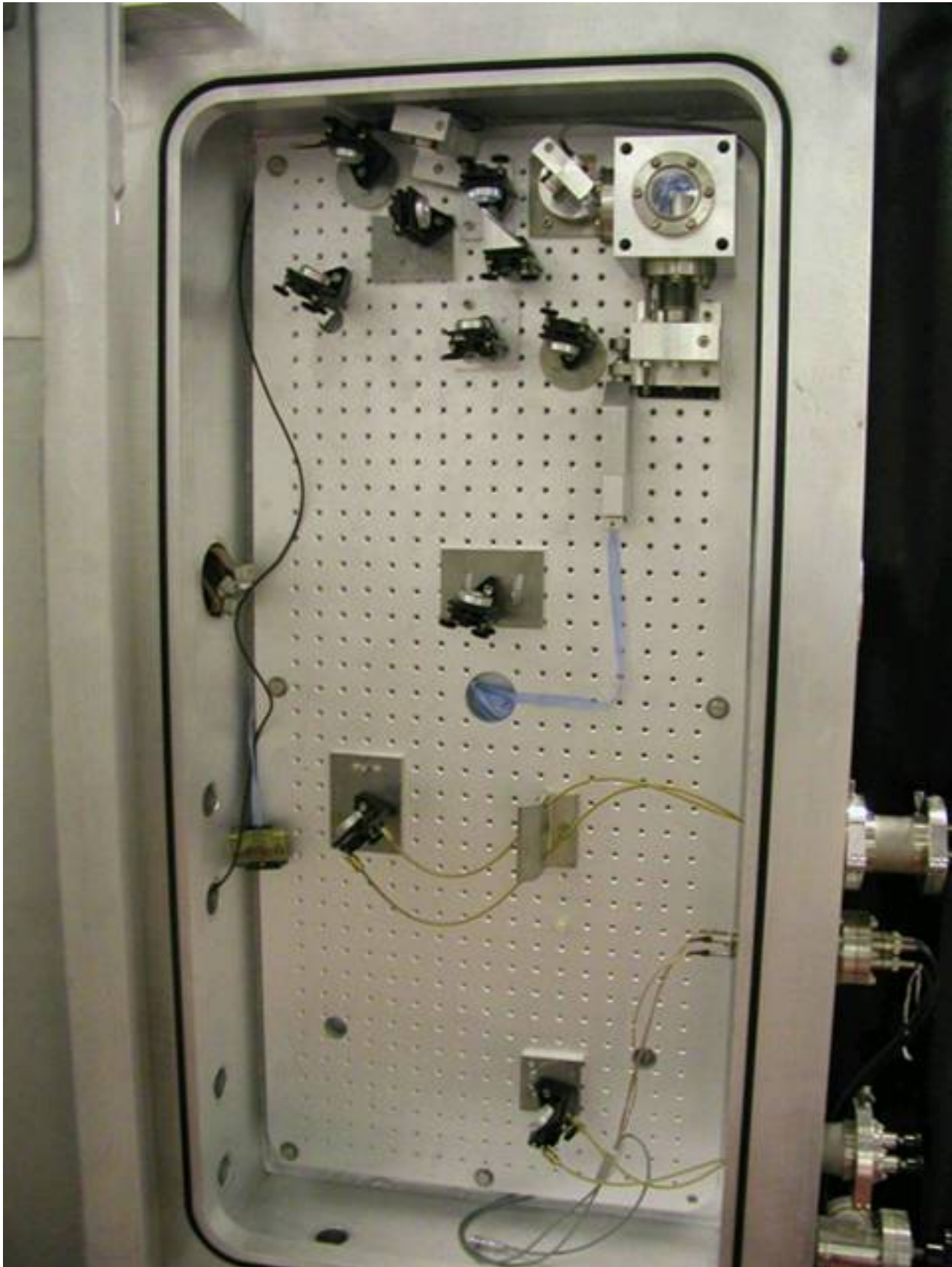


Figure 7. Inside view of the switchyard showing the optical

components.

When heading towards BL1.4.3 and BL1.4.4, the light beam exits the diamond window that ends the UHV, and enters the rough-pumped switchyard pictured in Figure 7. The 1.4 front end collects 10 mrad of light vertically and 40 mrad horizontally which means that the horizontal dimension of the light beam is growing in size four times as rapidly as the vertical. The M1/M2 chamber flips the vertical and horizontal directions such that by the light now has its vertical dimension growing fastest. To compensate for this and end up with a roughly square collimated beam, we first collimate the faster growing vertical portion of the beam using a 150mm focal length cylindrical mirror (denoted vertically collimating mirror in Figure 1.8). The horizontal beam size is then allowed to continue growing until it is the same dimension (by traveling 4 times the distance). Therefore a second cylinder with a 600mm focal length is placed at an appropriate distance (labeled horizontally collimating mirror in Figure 1.8). Each is set up so that the angle that the light must travel away from the ideal normal incidence is 10 degrees or less. The remaining three mirrors in the switchyard are flat. The now collimated light is sent to the FTIR spectrometers as will be described in greater detail in the following sections.

Vacuum Safety Interlock System

This beamline (like all beamlines at the ALS) has a set of interlock systems to ensure the safety of users as well as prevent damage to the beamline and storage ring in case of accidents. The main safety interlocks are controlled by a special computer installed in the beamline equipment control racks. The screen will then show a small schematic drawing of the beamline along with vacuum gauge readings, and vacuum valve status. During normal operating conditions, you should see every status indicator colored green. A flashing yellow means that at some time in the recent past the indicator was showing something bad, but now it is ok again. A red color indicates that a part of the system is out of the proper range and something needs to be done about it before the beam can be used. Most problems are not fixable by the user, so if you see something out of the ordinary and the ALS is otherwise in normal operations, please call Mike or Hans, or the control room.